Health Consultation

Evaluation of Indoor Air Samples
Eastside Laundry-Cleaners site
Olympia, Thurston County, Washington

July 19, 2002

Prepared by
The Washington State Department of Health
under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

Foreword

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations allow DOH to respond quickly to a request from concerned residents for health information on hazardous substances. It provides advice on specific public health issues. DOH evaluates sampling data collected from a hazardous waste site or industrial site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

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Glossary

Acute	Occurring over a short period of time. An acute exposure is one which lasts for less than 2 weeks.
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Aquifer	An underground formation composed of materials such as sand, soil, or gravel that can store and/or supply groundwater to wells and springs.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate it's ability to cause cancer in humans.
Carcinogen	Any substance that can cause or contribute to the production of cancer.
Chronic	A long period of time. A chronic exposure is one which lasts for a year or longer.
Comparison value	A concentration of a chemical in soil, air or water that, if exceeded, requires further evaluation as a contaminant of potential health concern. The terms comparison value and screening level are often used synonymously.

Contaminant	Any chemical that exists in the environment or living organisms that is not normally found there.
Dose	A dose is the amount of a substance that gets into the body through ingestion, skin absorption or inhalation. It is calculated per kilogram of body weight per day.
Exposure	Contact with a chemical by swallowing, by breathing, or by direct contact (such as through the skin or eyes). Exposure may be short-term (acute) or long-term (chronic).
Groundwater	Water found underground that fills pores between materials such as sand, soil, or gravel. In aquifers, groundwater often occurs in quantities where it can be used for drinking water, irrigation, and other purposes.
Hazardous substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Lowest Observed Adverse Effect Level (LOAEL)	LOAELs have been classified into "less serious" or "serious" effects. In dose-response experiments, the lowest exposure level at which there are statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An amount of chemical that gets into the body (i.e., dose) below which adverse health effects are not expected. MRLs are derived by ATSDR for acute, intermediate, and chronic duration exposures by the inhalation and oral routes.

Monitoring wells	Resource protection wells installed at locations on or off a hazardous waste site so groundwater can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and type of contaminant.
No apparent public health hazard	Sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.
Inhaled Dose	The amount of chemical inhaled (breathed) into the body (i.e., dose).
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb.
U.S. Environmental Protection Agency (EPA)	Established in 1970 to bring together parts of various government agencies involved with the control of pollution.
Volatile organic compound (VOC)	An organic (carbon-containing) compound that evaporates (volatilizes) easily at room temperature. A significant number of the VOCs are commonly used as solvents.

Background and Statement of Issues

The Washington State Department of Health prepared this health consultation in response to concerns raised by the owners of a small business (Farmer's Insurance) and the Thurston County Public Health and Social Services Department (TCHD) regarding potential exposure to tetrachloroethylene (PCE) and other related volatile organic compounds (VOCs) in indoor air at Farmer's. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Farmer's and another adjacent business (Roy's Thriftway Barber shop, or Roy's) is located near Eastside Laundry (Eastside), in a small "strip mall" near the intersection of Turner Street and State Street, in Olympia, Washington. Land use in the area is residential and light commercial (Appendix A).

Soil and groundwater testing conducted in spring 2000 and summer 2001 in the immediate vicinity of Eastside revealed elevated levels of PCE in the groundwater, and low levels of PCE, toluene, xylenes, and ethylbenzene in subsurface soils. Soil and groundwater sampling results are presented in Table B1. The owners of Farmer's have worked there for over 30 years, and are concerned about potential exposure to chemicals in indoor air from Eastside drycleaners. Although owners/employees at the other two businesses (Roy's and Eastside) have not expressed any health concerns, they were included in the evaluation because of their proximity to one another. The current property owner is investigating the Eastside site under the authority of the Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA).

Low concentrations of PCE were first discovered in subsurface soil near the Eastside facility during investigations in March 2000. Subsequent investigations conducted in the same area during April and August 2001 revealed low levels of PCE and petroleum hydrocarbons in the soil, and PCE in the groundwater. Subsurface soil samples were collected from interior and exterior borings directly beneath and outside the Eastside building. Groundwater samples were collected in August 2001 at two locations outside of the building (Appendix A). The source of soil and groundwater contamination is believed to be historic releases from the Eastside facility while under different owners/operators.

Soil

The Eastside site is situated approximately 180 feet above sea level. Area soils are classified as Yelm fine sandy loam. The soil is moderately well drained and is formed in volcanic ash and glacial outwash. Permeability is moderately rapid.

PCE was detected in subsurface soil at depths between 3 and 85 feet below ground surface (bgs). The maximum concentration (39.9 parts per million, or ppm) was found in a sample collected 5 feet bgs, next to the "closed loop" drycleaning machine at Eastside. Lower levels of toluene, ethylbenzene, and xylenes were detected in soil at depths between 5 and 19 feet bgs. According to boring logs, faint to very strong PCE odors were encountered in interior soil borings at depths

between 3 and 8 feet bgs. The borings were drilled through the concrete floor, at three locations around the drycleaning machine. No odors were detected in exterior borings drilled beneath the asphalt parking lot outside of the businesses.

Contaminant levels measured in subsurface soil were low. The entire site is overlain by either operating businesses or an asphalt parking lot. As a result, direct contact with the contaminated soil is unlikely, and will not be evaluated further in this health consultation. Soil sampling results are summarized in Appendix B, Table B1.

Groundwater

Two groundwater monitoring wells were installed during the August 2001 site investigation to further characterize the subsurface soil and groundwater. Groundwater was encountered at 86 feet bgs. Localized groundwater flow direction could not be determined since only two monitoring wells were installed. Based on available site information, groundwater gradient is presumed to flow west-northwest.

Groundwater samples were collected from MW-1 on August 7, 2001, and from both monitoring wells on August 24, 2001. PCE was the only chemical detected. PCE levels in groundwater at MW-1 were 480 µg/l and 84 µg/l (55 feet bgs), and 11 µg/l in MW-2 (90 feet bgs). Groundwater in the vicinity of the Eastside site is not believed to be a source of domestic (i.e., drinking or cooking) water. However, area homes have not been surveyed to confirm that no drinking water wells are near the site. PCE levels in groundwater are summarized in Table B1.

Indoor Air

Because of concerns expressed by the owners of Farmer's about the potential for exposure to chemicals in indoor air from subsurface migration of VOCs, or from aboveground sources at Eastside Laundry, DOH and TCHD conducted indoor air monitoring at Farmer's and Roy's from January 8-9, 2002, and at Eastside from February 6-7, 2002. Contaminants of concern in indoor air included those chemicals previously detected in soil (PCE, TCE, DCE, vinyl chloride, benzene, ethylbenzene, toluene, and xylenes). An Exposure Investigation (EI) workplan outlining the procedures used to collect and analyze the air samples was prepared prior to the sampling. Sampling locations are shown in Appendix A. One of the two sampling canisters placed inside Farmer's (in the main work area) malfunctioned, and could not be used.

Background

Background is defined here as the amount of PCE and TCE expected to be present in air without any known contribution from a particular source. The background levels cited in this health consultation were obtained from various indoor air studies conducted throughout urban areas of the U.S. Sources of background levels of PCE and TCE can include household products, recently dry-cleaned clothes, solvents, paints, etc.

Elevated levels of PCE were detected in indoor air in all three businesses, while TCE was only elevated at the Eastside Laundry. Other VOCs detected were either below levels of health concern or typical of background levels found in urban, indoor air (Table B2 and B4).

The business and property owners were informed of the air sampling results, along with a letter explaining DOH's initial evaluation. They were also informed that a health consultation would be prepared explaining the sampling results in more detail, along with recommendations to reduce or eliminate exposures, if appropriate.

Discussion

Environmental sampling data were screened using ATSDR, U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) health-based criteria (comparison values). Contaminant concentrations below comparison values are unlikely to pose a health threat, and were not further evaluated. Contaminant concentrations exceeding comparison values do not necessarily pose a health threat, but were further evaluated to determine whether they are at levels which could result in adverse human health effects.

PCE levels in indoor air at Eastside Laundry, Roy's, and Farmer's, and TCE levels in indoor air at Eastside exceeded background levels and respective health comparison values and were evaluated for both cancer and noncancer health effects.

PCE is a manufactured compound widely used for drycleaning fabrics and as a metal degreaser. It is also used as an intermediate in the manufacturing of other products. It is a nonflammable liquid at room temperature, evaporates easily into the air, and has a sharp, sweet odor at high concentrations.[1] TCE is primarily used as a metal degreaser, particularly in the automotive and metals industries. It is also found in some household products, such as typewriter correction fluid, paint removers, adhesives, and spot removers.[2]

Estimated exposures, exposure assumptions, cancer, and noncancer risks for PCE and TCE are provided in Table B3. Estimated exposures and risks are based on the results of a single sampling event, and therefore may not represent conditions during other times of the year. The sample collected at Eastside Laundry was from a small room in the back of the business, near the drycleaning machine, where exposures are considerably less than 8 hours per day. Contaminant levels in the main laundry area, where people spend more time, were not measured but are expected to be lower since it is a larger room and further from the drycleaning machine, a suspected source of PCE. Once laundry is removed from the drycleaning machine, it is taken to the press shop at the opposite end of the strip mall for pressing and hanging. In the process, the laundry is carried by Farmer's and Roy's.

Noncancer effects

To evaluate possible noncancer effects from exposure to PCE and TCE in indoor air, the levels were compared to their respective non-cancer comparison value [EPA inhalation reference concentration (RfC) or ATSDR chronic minimal risk level (MRL)]. The MRL and RfC are concentrations in air below which noncancer health effects are not expected.

EPA Reference Concentration (RfC) and ATSDR Chronic Minimal Risk Level (MRL)

Inhalation reference concentrations (RfCs) and chronic minimal risk levels (MRLs) are concentrations in air below which noncancer health effects are not expected. RfCs and MRLs are based upon 24-hour exposures.

RfCs and MRLs are set below toxic effect levels in order to provide an added measure of safety. The higher the chemical concentration is above the RfC or MRL, the closer it will be to an actual toxic effect level. If a comparison value is exceeded, the relevant toxicity studies are evaluated to determine whether adverse health effects would be expected.

Exposure to PCE in indoor air at Eastside Laundry is four-fold above the RfC, indicating some potential for noncancer adverse health effects (see footnote beneath Table B2 for an explanation of the exposure calculation adjustment). All estimated TCE exposures, and PCE exposures at the other businesses, were at or below their respective RfCs, and are not expected to result in adverse noncancer health effects.

Numerous occupational studies have shown that chronic exposures to high levels of PCE in air (higher than levels detected at Eastside businesses) can effect the liver, kidneys, and neurological system, among others. The chronic MRL for PCE is based on neurological effects observed during a 10-year occupational study. Compared to 30 unexposed women, significantly prolonged reaction times were reported in 60 women occupationally exposed to PCE at a median concentration of 15,000 ppb for an average of 10 years.[1] Although above the MRL, the PCE level at Eastside Laundry was 21 times below the concentration which resulted in neurological effects in the occupational study.

The National Center for Environmental Assessment (NCEA) is currently finishing a revised human health risk assessment on TCE. This assessment will present EPA's most current evaluation of the potential health risks from exposure to TCE. The mechanistic information suggests some risk factors that may make some populations more sensitive, and that TCE could affect children and adults differently. TCE exposure is associated with a number of health effects, including neurotoxicity, immunotoxicity, developmental toxicity, liver and kidney toxicity, and endocrine effects.[3] The RfC for TCE is based on critical effects on the central nervous system, liver, and endocrine system.[4] The TCE level in Eastside Laundry and Roy's was below the RfC (adjusted to account for the less than 24-hour exposure), indicating that TCE exposures are not likely to result in these kinds of health effects.

Cancer effects - Tetrachloroethylene (PCE)

PCE carcinogenicity characterization has a long history. Although it has not been shown to cause cancer in people, the U.S. Department of Health and Human Services has determined that it may reasonably be anticipated to be a carcinogen. The International Agency for Research on Cancer (IARC) has determined that it is probably carcinogenic to humans, based on limited human evidence and sufficient evidence in animals. EPA is currently reassessing PCE toxicity, and has not adopted a final position on the weight-of-evidence classification.[5]

Although a number of human studies (primarily epidemiology studies of dry-cleaning workers) suggest the possibility of increased cancer incidences from exposure to PCE, particularly esophageal and bladder cancers, it has not been shown to definitively cause cancer in humans. Other cancers suspected of being associated with exposures to high levels of PCE (much higher than levels measured in Eastside businesses) include intestinal, pancreatic, lung, kidney, skin, colon, and lymphatic/hematopoietic cancer. Following inhalation exposure to high levels of PCE, mononuclear cell leukemia was observed in rats and hepatic tumors were observed in mice. However, because both mononuclear cell leukemia and hepatic tumors are common in rats and mice, respectively, the relevance of these tumors to humans is not clear.[1]

The concentrations of PCE in indoor air detected in the Eastside businesses were hundreds to thousands of times lower than the cancer effect levels (CEL) derived from the rodent studies discussed above. Although the cancer slope factor for PCE has been removed pending the reassessment, the previous slope factor can be used to estimate cancer risk. It should be noted that the reassessment could result in an increase in the estimated cancer risk. *The estimated increased lifetime risk of developing cancer from chronic exposure to the detected concentrations of PCE in indoor air ranged from very low to low, depending upon the business (see Table B3, and text box at right).*

Cancer Risk

Cancer risk estimates do not reach zero no matter how low the level of exposure to a carcinogen. Terms used to describe this risk are defined below as the number of excess cancers expected in a lifetime:

Term		# of Excess Cancers
moderate	is approximately equal to	1 in 1,000
low	is approximately equal to	1 in 10,000
very low	is approximately equal to	1 in 100,000
slight	is approximately equal to	1 in 1,000,000
insignificant	is less than	1 in 1,000,000

Cancer effects - Trichloroethylene (TCE)

Recent and extensive review of available data has led EPA to characterize TCE as "highly likely to produce cancer in humans." These findings are consistent with those of the International Agency on Research of Cancer (IARC, 1995) and the National Toxicology Program (NTP, 2000). This classification is based on sufficient evidence in animals and limited evidence in humans. The strongest evidence that TCE can cause cancer in humans comes from occupational

studies that have found increases in lung, liver and kidney cancers in workers exposed over several years.[3]

In experimental rodent studies, high doses of TCE administered to mice resulted in tumors of the lungs, liver, and testes. Other possible cancers associated with exposure to high levels of TCE include cancer of the bladder, stomach, prostate, kidney, and pulmonary system. TCE cancer effects levels (CELs), which were derived from lowest observed adverse effects levels (LOAELs) in chronic-duration studies on rats and mice, ranged from 100,000 ppb to 600,000 ppb.[2] *The levels of TCE detected in indoor air at Eastside Laundry and Roy's were thousands of times lower than these LOAELs.*

Although the data obtained from high-dose animal or worker exposure studies is not directly applicable to exposures at Eastside businesses, theoretical cancer risk estimates can be made based on this data. In order to estimate the increased lifetime cancer risk for persons assumed to be chronically exposed to the detected levels of TCE in indoor air, the current recommended EPA inhalation slope factor was used. *The increased cancer risk from TCE exposure is estimated to be low at Roy's and moderate at Eastside Laundry.* The TCE level in Roy's was within the range of background, and therefore may not be associated with site.

Multiple Chemical Exposure

In almost every situation of environmental exposure, there are multiple contaminants to consider. The potential exists for these chemicals to interact in the body and increase or decrease the potential for adverse health effects. The vast number of chemicals in the environment make it impossible to measure all of the possible interactions between these chemicals. Individual cancer risk estimates can be *added* since they are measures of probability. When estimating noncancer risk, however, similarities must exist between the chemicals if the doses are to be added. Groups of chemicals that have similar toxic effects can be added such as PCE and TCE, which cause liver toxicity. Although some chemicals can interact to cause a toxic effect that is *greater than* the added effect, there is little evidence demonstrating this at concentrations commonly found in the environment.

The combined exposures of people to the contaminants of concern detected in indoor air (PCE and TCE) were considered, and are presented in Table B3. As the Table shows, the combined effect of PCE and TCE was not significant for noncancer risks, but resulted in slightly increased combined cancer risks. The risk from exposure to TCE at Roy's is comparable to the risk from background levels of TCE commonly found in urban indoor air.

Exposure Pathways and Children

ATSDR's Child Health Initiative recognizes that the unique vulnerabilities of infants and children deserve special emphasis with regard to exposures to environmental contaminants. Infants, young children, and the unborn may be at greater risk than adults from exposure to particular contaminants. Exposure during key periods of growth and development may lead to malformation of organs (teratogenesis), disruption of function, and even premature death. In certain instances, maternal exposure, via the placenta, could adversely effect the unborn child.

After birth, children may receive greater exposures to environmental contaminants than adults. Children are often more likely to be exposed to contaminants from playing outdoors, ingesting food that has come into contact with hazardous substances, or breathing soil and dust. Pound for pound body weight, children drink more water, eat more food, and breathe more air than adults. For example, in the United States, children in the first 6 months of life drink 7 times as much water per pound as the average adult. The implication for environmental health is that, by virtue of children's lower body weight, given the same exposures, they can receive significantly higher relative contaminant doses than adults.

Since exposures to infants and young children at the Eastside businesses are expected to be infrequent (i.e., much less than the 8-hours/day, 5 days/week assumptions used for this health consultation), the risks are minimal. In addition, levels of PCE and TCE that produced developmental and reproductive effects in relevant toxicity studies were much higher than the levels detected at this site.[1, 2]

Conclusions

1. No public health hazard exists as a result of the low levels of PCE and other VOCs detected in subsurface soil at the Eastside Laundry-Cleaners (Eastside) site. The chemicals were detected underneath the concrete floor of existing structures, or underneath an asphalt parking lot, where direct contact with the chemicals is unlikely.

2. PCE was the only contaminant detected in groundwater. Although PCE levels exceed drinking water standards and other health-based levels of concern, groundwater is not believed to be a source of area drinking water, and therefore poses no public health hazard.

3. Numerous VOCs were detected in indoor air at Eastside, Farmer's Insurance (Farmer's), and Roy's Thriftway Barber Shop (Roy's). PCE was elevated in all three businesses, and TCE was elevated at Eastside. Other chemicals were detected, but below levels of health concern, or within background levels commonly found in urban indoor air. Based on the limited indoor air sampling conducted, DOH concludes the following:

   - Long-term exposures to PCE in indoor air at Eastside could result in mild neurological effects for sensitive persons, although the concentration was still 21 times below the level that produced these effects in the relevant occupational study.
   - A low to moderate increase in cancer risk is also associated with the levels of PCE and TCE found at Eastside and Roy's. The lower levels found at Farmer's represent only a very low increase in cancer risk It is important to note that estimated exposures at these businesses were still from 140 to 1,600 times below the level which caused cancer in the relevant animal studies.
   - Other detected chemicals were below levels of health concern, similar to background levels typical of urban indoor air, and do not represent a health hazard.

4. Faint to very strong PCE odors were encountered in soil from three to eight feet beneath Eastside Laundry. These odors indicate the likelihood of high levels of PCE in subsurface soil gas in the immediate vicinity of Eastside Laundry, a potential source of PCE in indoor air.

5. It is not clear whether the source of PCE and TCE is from current operations at Eastside, from subsurface soil gas underneath Eastside, from openings between businesses (i.e., cracks in the walls or piping and ventilation ducts), from recently drycleaned laundry carried past the adjacent businesses on the way to the press shop, or a combination thereof.

Recommendations/Public Health Action Plan

1. Follow-up indoor air sampling should be conducted in the main room at Eastside and Farmer's to determine whether air concentrations of PCE and TCE are present at levels of health concern. Air sampling should also be repeated in the three businesses following any subsequent operational/ventilation improvements, soil gas remediation, or other remedial actions to reevaluate indoor air VOC levels.

   - DOH will follow up with TCHD, Ecology, and the property owners on this issue. If subsequent sampling is conducted, the results should be provided to DOH for evaluation.

2. To evaluate possible sources of PCE and TCE in indoor air, subsurface soil gas in the immediate vicinity of Eastside should be tested for these chemicals. The Johnson & Ettinger vapor intrusion model contains useful guidance for soil gas sampling that can be consulted when developing a sampling plan.

   - DOH will follow up with the property owner's consultants on this issue. If subsequent soil gas testing reveals high levels of PCE and/or other VOCs, appropriate remedial actions to reduce the levels should be taken.

3. Localized groundwater should be more thoroughly characterized to evaluate whether it could be an ongoing source of PCE and TCE detected in indoor air, and to determine groundwater gradient.

   - Private drinking water wells are not believed to be used in the area. Domestic water in this part of Olympia is currently supplied by the city. DOH will follow up with TCHD to make sure there are no private drinking water wells being used in the immediate vicinity of the Eastside site that could be threatened by the contaminated groundwater.

4. Adequate ventilation should be maintained within the business work areas to promote dispersion and reduce the accumulation of chemical vapors.
   - DOH and TCHD will discuss this with the business owners/operators.

5. Any PCE (waste, or product) stored at Eastside that is not being used for drycleaning purposes should be removed from the premises and/or properly disposed of. PCE and other volatile chemicals stored at Eastside should be covered at all times to reduce emissions. The owners/operators of Eastside Laundry should contact drycleaning industry associations, the Washington State Department of Labor and Industries, the Olympic Air Pollution Control Authority, and/or EPA for up-to-date recommendations on ways to reduce fugitive emissions. These could include some or all of the following: general housekeeping, vapor recovery, equipment modification, waste solvent recovery, and chemical or process substitution.

   - DOH and TCHD will discuss these housekeeping recommendations and options with the owners/operators of Eastside. Various industry pamphlets are available that provide guidance on these subjects.

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Appendix A: Figures

Appendix B: Tables

Table B1

Chemicals detected in soil and groundwater
*Eastside Laundry-Cleaners site, Olympia, Washington**

Chemical	March 2, 2000		April 3 and 4, 2001		August 1, 2, and 22, 2001	
	Media		Media		Media	
	Soil (mg/kg) 14' - 16' BGS	Groundwater (µg/liter)	Soil (mg/kg) 1' - 34' BGS	Groundwater (µg/liter)	Soil (mg/kg) 10' - 105' BGS	Groundwater (µg/liter) 55' - 90' BGS
Tetrachloroethylene (PCE)	0.17 - 0.54	NA	ND - 39.9 (5' BGS)	NA	ND - 0.82	11 - 480
Toluene	ND	NA	ND - 1	NA	ND	ND
Total Xylenes	ND	NA	ND - 1.8	NA	ND	ND
Ethylbenzene	ND	NA	ND - 0.23	NA	ND	ND

mg/kg = milligrams of chemical per kilogram of soil (equals part per million)
µg/liter = microgram of chemical per liter of water (equals part per billion)
ND = not detected
NA = not analyzed
BGS = below ground surface

* Health comparison values are not listed in this Table since direct contact with the soil and groundwater is not occurring. This table was included in this health consultation to develop contaminants of concern for the indoor air pathway.

Table B2. *Chemicals detected in indoor air during January/February 2002 indoor air investigation Eastside Laundry-Cleaners site, Olympia, Washington +*

Chemical	Chemical concentration (in micrograms per cubic meter, or µg/m3)			Cancer Health Comparison Value (in micrograms per cubic meter)	Noncancer Health Comparison Value (in micrograms per cubic meter)	Cancer Class
	Eastside Laundry	Roy's Barbershop	Farmer's Insurance			
Tetrachloroethylene (PCE)	4,820 (711 ppb)	1,268 (187 ppb)	419 (62 ppb)	3.3 (EPA Region 9)	271 (40 ppb) * (ATSDR chronic MRL) (adjusted MRL ~ 1,084 µg/m3)	EPA-UR IARC-2A NTP-2
Trichloroethylene (TCE)	91 (17 ppb)	5.8 (1 ppb)	ND	0.515 (MTCA Method B)	40 (7.4 ppb) * (EPA RfC) (adjusted RfC ~ 160 µg/m3)	** EPA-UR IARC-3 NTP-2
1,1-Dichloroethylene (1,1-DCE)	ND	ND	ND	0.02 (ATSDR CREG)	33 (EPA Region 9)	EPA Class C
Vinyl chloride	ND	ND	ND	0.1 (ATSDR CREG)	45.7 (MTCA Method B)	EPA Class A
Benzene	NA	1.5 ppbv *** (4.8 µg/m3)	NA	0.1 (ATSDR CREG)	2.72 (MTCA Method B)	EPA Class A

Table B2 (cont.). *Chemicals detected in indoor air during January/February 2002 indoor air investigation. Eastside Laundry-Cleaners site, Olympia, Washington +*

Chemical	Chemical concentration (in micrograms per cubic meter)			Cancer Health Comparison Value (in micrograms per cubic meter)	Noncancer Health Comparison Value (in micrograms per cubic meter)	Cancer Class
	Eastside Laundry	Roy's Barbershop	Farmer's Insurance			
Toluene	37	21	1.9 ***	NA	301 (80 ppb) (ATSDR chronic MRL)	EPA Class D
Ethylbenzene	4.5 ***	2.1***	ND	NA	1,000 (EPA RfC)	EPA Class D
m,p-Xylenes	16 ***	8.1 ***	4.6 ***	NA	434 (100 ppb) (ATSDR chronic MRL/total xylenes)	EPA Class D
o-xylene	5.6 ***	2.8 ***	1.46 ***	NA	434 (100 ppb) (ATSDR chronic MRL/total xylenes)	EPA Class D

Shaded cell: Chemical exceeded a health comparison value, and was further evaluated.
ppb = parts per billion
+ The chemicals and corresponding concentrations listed in Table B2 were taken from the laboratory analysis reports referenced at the end of this report.
* The RfC and chronic MRL are based on a 24-hours/day, 7 days/week, 52 weeks/year residential exposure scenario. To account for the reduced (i.e., 8-hours/day, 5-days/week, 50 weeks/year) worker scenario used for this health consultation, the RfC was corrected (raised) by a factor of approximately 4
Chronic MRL: ATSDR chronic Minimal Risk Level (exposure > 365 days)
** EPA-UR: Under review - U.S. Environmental Protection Agency
IARC-3: Not classifiable - International Agency for Research on Cancer
NTP-3: Not classified - National Toxicology Program - National Institute for Environmental Health Sciences
IARC-2A: Probably carcinogenic to humans (limited human evidence; sufficient evidence in animals)
NTP-2: Reasonably anticipated to be a carcinogen
ND = not detected above the practical quantitation limit (PQL)
NA = not analyzed
MTCA: Washington State Department of Ecology Model Toxics Control Act
CREG: ATSDR Cancer Risk Evaluation Guide

RfC: EPA Reference Concentration
ppbv = parts per billion by volume
*** These levels are similar to background levels of these chemicals measured in indoor air in urban environments in the U.S. (see Table B4).
EPA Class A: Human Carcinogen
EPA Class C: Possible human carcinogen (no human studies, limited animal studies)
EPA Class D: Not Classifiable

Table B3. *Estimated Exposure Doses and Health Risks. Eastside Laundry-Cleaners site, Olympia, Washington.*

Location	Chemical	Measured air concentration ($\mu g/m^3$)	Receptor population	Exposure duration (years)	Inhalation Rate * (m^3/day)	Inhaled dose (mg/kg/day)	Estimated increased cancer risk	** Number of times above RfC, or fraction of RfC
Eastside Laundry	PCE	4,820	Adult	25	5	0.23	1×10^{-4}	4.5
	TCE	91				0.004	6×10^{-4}	0.6
							Total = 7×10^{-4}	*Total = 5.1*
Roy's Barbershop	PCE	1,268	Adult	25	5	0.06	4×10^{-5}	~ 1
	TCE	5.8				0.0003	4×10^{-5}	0.03
							Total = 8×10^{-5}	*Total ~ 1*
Farmer's Insurance	PCE	419	Adult	25	5	0.02	1×10^{-5}	0.4

* The 5 m^3/day inhalation rate used in the exposure assessment is approximately equal to one-third of the EPA recommended 15.2 cubic meters/day average 24-hour inhalation rate for adult, long-term exposures. The 5 m^3/day inhalation value approximates an 8-hour work day, and also closely corresponds to EPA's suggested short-term (8-hour) adult inhalation rate for light to sedentary activities, such as light office work.

** To account for the reduced (i.e., 8-hours/day, 5-days/week, 50 weeks/year) worker scenario in this health consultation, the RfC was corrected (raised) by a factor of approximately 4.

Table B4. Contaminants detected in indoor air at the Eastside Laundry site compared to median indoor air background levels throughout the U.S. (units are in ug/m^3)

Contaminant	**Maximum Concentration**	**Background Level** (Indoor Median)	**Source of Background Level**
Benzene	4.8	10	Shah & Singh
Tetrachloroethylene	4,820	5	Shah & Singh
Trichloroethylene	91	0.7	Shah & Singh
*Toluene	37	6.2	Shah & Singh
Ethylbenzene	4.5	4.8	Shah & Singh
m,p-Xylenes	16	6.2 - 16	Breen and Wallace, 1986 Median Concentration
o-Xylene	5.6	2.2 - 11	Breen and Wallace, 1986 Median Concentration

Shaded cell = chemical exceeded background level in at least one sample location.
* Although toluene exceeded background, it was below its respective health comparison values, and does not pose a health hazard.

Appendix C: Exposure Dose Calculations

This section provides the calculated exposure doses and assumptions used for each completed exposure pathway. The dose estimates for each of these pathways are described in the discussion section of the document. Maximum concentrations are used to calculate these doses, representing a "worst-case" scenario that may overestimate actual exposure.

The following exposure dose equations and exposure assumptions were used to calculate the doses, cancer, and noncancer risks in Tables B3 and C1.

Inhaled Dose - Employees

Noncancer

$$IhD = \frac{C_{air} \textbf{ x } Inh \textbf{ x } CF \textbf{ x } EF \textbf{ x } ED}{BW \text{ x } AT_{noncancer}}$$

Cancer

$$IhD = \frac{C_{air} \textbf{ x } Inh \textbf{ x } CF \textbf{ x } EF \textbf{ x } ED}{BW \textbf{ x } AT_{cancer}}$$

Table C1. Cancer risk calculations for indoor air exposure of employees at the Eastside Laundry-Cleaners site, Olympia, Washington

Receptor Population	Exposure Route	Contaminant	Maximum Concentration (ug/m^3)	Cancer Slope Factor [a] (mg/kg/day)	Cancer Risk
Adult	Inhalation	TCE	91	0.4	6×10^{-4}
		PCE	4,820	0.002	1×10^{-4}

a = TCE cancer risk calculations in this health consultation are based upon the upper range of cancer slope factors provided in EPA's draft health risk assessment for TCE.

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Certification

This Health Consultation was prepared by the Washington State Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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